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TITLE OF THE INVENTION

REFRIGERANT RECOVERY DEVICE AND REFRIGERANT RECOVERY
METHOD BY USE OF THE SAME

5 BACKGROUND OF THE INVENTION

The present invention relates to a refrigerant
recovery device, and a refrigerant recovery method by use of
the same.

As refrigerants used for a refrigeration unit such
10 as a refrigerator, there have conventionally been available
dichlorodifluoromethane (R-12) and R-500 constituted of R-12
of an azeotropic mixed refrigerant and 1,1-difluoroethane (R-
152a) which have the dangers of destroying an ozone layer.
As an alternative refrigerant in which a content of a
15 chlorine group having a small danger of destroying the ozone
layer but having a high global warming effect is reduced, for
example, there is chlorodifluoromethane (HCFC-22). As
refrigerants which contain no chlorine groups, for example,
there are difluoromethane (HFC-32, R-32), trifluoromethane
20 (HFC-23, R-23), pentafluoroethane (HFC-125, R-125), 1,1,1,2-
tetrafluoroethane (HFC-134a, R-134a), 1,1,1-trifluoroethane
(HFC-143a, R-143a). There is a fluorocarbon-based
refrigerant (FC-based refrigerant) which contains neither
chlorine groups nor hydrogen, or a mixture thereof.
25 Additionally, there are combustible hydrocarbons such as
propane, butane and penta, helium, ammonia, and air.

When a need arises to recover the refrigerant from a

refrigeration circuit because a household refrigerator, an air conditioner or an industrial refrigerator which uses one of the aforementioned refrigerants has been used up, a method is employed, which sucks the refrigerant by using a
5 refrigerant recovery machine to place it outside the refrigeration circuit, and liquefies the refrigerant to feed it into a cylinder. Alternatively, a method is employed which runs the refrigerator or the like to liquefy the refrigerants in the refrigeration circuit (pump-down running),
10 sucks the liquefied refrigerants by using the refrigerant recovery machine after all the refrigerants are liquefied to place them outside the refrigeration circuit, and then feeds the refrigerants into the cylinder.

The former method is convenient when many used-up
15 household refrigerators or the like are collected at the place of the refrigerant recovery machine to be processed. However, in the case of a refrigeration unit such as a refrigerator located in a faraway region, and an industrial refrigerator, especially an equipment such as a medical
20 equipment in which a special refrigerant is sealed, collection itself is difficult. Transportation of a large and heavy refrigerant recovery machine to a far place is very hard, much time and labor are necessary, and costs are increased. Additionally, there is a problem of impossible
25 recovery of a gas refrigerant for an extra-low temperature freezer by the recovery machine.

In the latter case, there are no problems as long as

all the refrigerants can be liquefied by the pump-down running. However, if refrigerants are low boiling point gas refrigerants or mixtures of low boiling point gas refrigerants and liquefied refrigerants which have boiling points higher than those of the gas refrigerants, there is a problem of impossible recovery because not all the refrigerants can be liquefied or the refrigerants can be liquefied only partially.

In order to solve the above problems, there have been presented a refrigerant recovery device comprising a refrigerant recovery main body, in which a solid adsorbent to adsorb a refrigerant is stored in a container, and a refrigerant recovery method using the device (e.g., see Japanese Patent Application Laid-Open No. 2000-65447).

However, if an activated carbon is used for the solid adsorbent, the activated carbon is difficult to be handled because it is finely powdered or granulated, storage of the activated carbon in the container and replacement thereof are difficult, measurement takes time and labor, and there is a problem of a scattered loss of the activated carbon outside the container. When the refrigerant recovery device is connected to the refrigeration circuit, and a gas in a refrigerant recovery tank is vacuumed to be discharged before the refrigerant of the refrigeration circuit is recovered, there is a problem that fine grains of the activated carbon are discharged from the container, and sucked into a vacuum pump.

SUMMARY OF THE INVENTION

A first object of the present invention is to provide a compact and potable refrigerant recovery device which can easily store an activated carbon in a container and replace the activated carbon with good handleability of the activated carbon but without any problem of a scattered loss of the activated carbon outside, and which can recover a refrigerant at low costs without any problem of sucking into a vacuum pump when a gas in a refrigerant recovery tank is vacuumed to be discharged.

A second object of the present invention is to provide a method for easily recovering a refrigerant from a refrigeration circuit of a refrigeration unit at low costs by using the refrigerant recovery device.

That is to say, to solve the above problems, a first aspect of the present invention is directed to a refrigerant recovery device comprising a refrigerant recovery tank which stores an activated carbon for adsorbing a refrigerant, wherein the recovery tank is equipped with a detachable cap, and the activated carbon is wrapped in unwoven cloth finer than a grain diameter of the activated carbon, and stored in the recovery tank.

Since the activated carbon is wrapped in unwoven cloth finer than a grain diameter of the activated carbon, and stored in the recovery tank, handleability is improved, and a problem of a scattered loss to the outside is

eliminated. A cap detachably attached to the recovery tank is opened/closed to enable handling of the activated carbon in its wrapped state in the unwoven cloth, and storage and replacement of the activated carbon can be easily carried out.

5 Additionally, since the activated carbon is wrapped in the unwoven cloth finer than the grain diameter of the activated carbon, and stored in the recovery tank, there is no problem of sucking into the vacuum pump when the gas in the refrigerant recovery tank is vacuumed to be discharged, the
10 refrigerant can be recovered at low costs, and the device can be made compact and portable.

A second aspect of the present invention is directed to a refrigerant recovery method comprising a step of connecting the refrigerant recovery device of claim 1 to a
15 refrigeration circuit, and a step of vacuuming a gas in a refrigerant recovery tank to discharge the gas before a refrigerant of the refrigeration circuit is recovered.

The refrigerant can be efficiently recovered if the refrigerant of the refrigeration circuit is recovered after
20 the gas in the refrigerant recovery tank is vacuumed.

A third aspect of the present invention is directed to the refrigerant recovery method, wherein a filter of unwoven cloth finer than a grain diameter of an activated carbon is arranged on a path of the vacuuming.

25 By arranging the filter of the unwoven cloth finer than the grain diameter of the activated carbon on the path of the vacuuming, the activated carbon is captured by the

filter even if the activated carbon is leaked from the refrigerant recovery tank during vacuuming. Thus, it is possible to prevent sucking into the vacuum pump.

A fourth aspect of the present invention is directed to the refrigerant recovery method, wherein a refrigerant is a low boiling point gas refrigerant or a mixture of a low boiling point gas refrigerant and a liquefied refrigerant which has a boiling point higher than that of the gas refrigerant.

Even in the case of the low boiling point gas refrigerant which cannot be liquefied by pump-down running, or the mixture of the low boiling point gas refrigerant and the liquefied refrigerant which has the boiling point higher than that of the gas refrigerant, the refrigerant can be recovered by adsorbing it on the activated carbon in the refrigerant recovery tank.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view illustrating a state in which a refrigerant recovery device of the present invention is connected to a refrigeration circuit of a refrigerator or the like.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Next, the preferred embodiment of the present invention will be described with reference to the accompanying drawing.

In FIG. 1, a reference numeral 1 denotes a refrigeration circuit of a refrigerator or the like on which a compressor 2 is mounted. The compressor 2 is sequentially connected to a condenser 3, a capillary tube 4 and an evaporator 5 to constitute a refrigeration circuit. A refrigerant recovery device 6 of the present invention is connected to the compressor 2 in the refrigeration circuit.

The refrigerant recovery device 6 comprises a duct 7 for connection to the refrigeration circuit, an opening/closing valve 8 disposed on the duct 7, a refrigerant recovery tank 10 which stores an activated carbon 9 to adsorb a refrigerant of the refrigeration circuit 1, etc. One end of the duct 7 is connected to a tip of a sealing-in pipe 11 for sealing a refrigerant in the compressor 2 of the refrigeration circuit 1. A reference numeral 12 denotes a pressure gauge.

The refrigerant recovery tank 10 is equipped with a detachable cap 13. The activated carbon 9 is wrapped in unwoven cloth 14 finer than a grain diameter of the activated carbon 9, and stored in the refrigerant recovery tank 10. A reference numeral 15 denotes a bolt/nut which detachably fixes the cap 13 to the refrigerant recovery tank 10. The activated carbon 9 wrapped in the unwoven cloth 14 is stored in the refrigerant tank 10, and then fixed by using the bolt/nut 15. In the case of replacing the activated carbon wrapped in the unwoven cloth 14 or the like, the bolt/nut 15 is removed to open the cap 13, whereby the activated carbon 9

can be integrally taken out from the refrigerant recovery tank 10.

A reference numeral 16 denotes a vacuuming line set in the cap 13, and 17 an opening/closing valve disposed in the vacuuming line 16. A reference numeral 18 denotes a filter which comprises unwoven cloth finer than a grain diameter of the activated carbon. When vacuuming is carried out in the refrigerant recovery tank 10, it is carried out by closing the opening/closing valve 8, opening the opening/closing valve 17 to connect the vacuuming line 16 to a not-shown vacuum pump, and actuating the vacuum pump.

By arranging the filter 18 in the vacuuming line 16, fine grains are captured by the filter even if the fine grains of the activated carbon are leaked from the refrigerant recovery tank 10 during vacuuming.

The refrigerant recovery device 6 is simple in constitution, compact and portable, easily transported and installed, and handling and an operation are easy.

According to the aforementioned constitution, when a need arises to recover the refrigerant in the refrigeration circuit because the refrigerator 1 has been used up or the like, the opening/closing valve 8 is opened, and the refrigerant flows in a direction indicated by an arrow to be adsorbed on the activated carbon 9 without using a suction pump or the like. Thus, it is possible to recover substantially all the refrigerants of the refrigeration circuit in the refrigerant recovery tank 10.

Vacuuming is executed beforehand in the refrigerant recovery tank 10, and the opening/closing valve 8 is opened during recovery. Thus, it is possible to more efficiently recover the refrigerant of the refrigeration circuit in the refrigeration recovery tank 10. That is, the opening/closing valve 8 is fired closed, and the opening/closing valve 17 is opened to connect the vacuuming line 16 to the not-shown vacuum pump. The vacuum pump is actuated to execute vacuuming, and vacuuming is carried out beforehand in the refrigerant recovery tank 10. When the refrigerant of the refrigeration circuit is recovered, the opening/closing valve 17 is closed, and the opening/closing valve 8 is opened, whereby the refrigerant can be adsorbed on the activated carbon 9 to be recovered.

The activated carbon used by the present invention is selected from activated carbons of powdered; granulated, fiber and molded shapes. The activated carbon used by the invention is made of a carbonaceous raw material such as a coconut husk, a coal, an oil-based pitch, or an oil carbon. Preferably, a specific surface area is $400 \text{ m}^2/\text{g}$ or higher by a BET method, more preferably $1000 \text{ m}^2/\text{g}$ or higher.

The amount of the activated carbon used by the invention is properly decided based on the amount of the refrigerant in the refrigeration circuit.

The unwoven cloth used by the invention is finer than a grain diameter of the activated carbon. A material may be, e.g., plastic, a carbon fiber, a natural fiber, a

metal fiber, a glass fiber or a ceramic fiber as long as the wrapped activated carbon is not put out from the texture of the unwoven cloth when the activated carbon is wrapped, but the refrigerant is passed through the texture and adsorbed on the activated carbon to be recovered, the activated carbon can be integrally handled in the wrapped state in the unwoven cloth, and storage and replacement of the activated carbon can be integrally carried out easily. There are no particular limitations on shapes and types. A porous film, a porous sheet, a bag, or various container types to be stored in the refrigerant recovery tank may be used.

Next, the present invention will be described more in detail by way of examples. Apparently, widely different examples can be constituted without departing from the spirit and scope of the invention. Thus, the specific examples are not limitative of the invention which is only limited by the appended claims.

(Example 1)

A test was conducted to recover a refrigerant by connecting the refrigerant recovery device of the present invention to a binary refrigeration circuit in which two refrigeration circuits shown in FIG. 1 were used.

Refrigerant: high-temperature side; R407D [difluoromethane, pentafluoroethane, 1,1,1,2-tetrafluoroethane] +6 pt, low-temperature side; R508 [trifluoromethane/hexafluoromethane mixed refrigerant]

Refrigerant charge amount: 205 g on the low-temperature side

Refrigerant recovery tank capacity: about 2.5 liters

Activated carbon: granular activated carbon using coconut husk in the form of pellets of 8 to 10 mesh and grain diameter 1.70 to 2.00 mm as a main raw material, the amount of use: 930 g, and the activated carbon, when used, was wrapped in unwoven cloth as shown in FIG. 1.

The refrigerant of the high-temperature side was recovered by a conventional method which used a recovery machine.

In the case of recovery of the refrigerant of the low-temperature side, the opening/closing valve 8 was first closed, the opening/closing valve 17 was opened to connect the vacuuming line 16 to the not-shown vacuum pump, the vacuum pump was actuated to execute vacuuming, and vacuuming was executed beforehand (3.6 Pa) in the refrigerant recovery tank 10. When the refrigerant was recovered, the opening/closing valve 17 was closed, the opening/closing valve 8 was opened, and the amount of the recovered refrigerant adsorbed on the activated carbon with the elapse of time, and pressure indicated by the pressure gauge 12 were measured.

The following shows results of the measurement.

Elapsed time (min.)	Amount of recovered refrigerant (g)	Pressure (MPaG)
0.5	-	0.02
5	171	-0.01
12	171	-0.01

Thus, a recovery rate of 83.4% was obtained in about 5 min. If the refrigerant can be recovered up to about pressure of -0.01 MPaG, no residual refrigerant is discharged from the refrigeration circuit into the atmosphere. The residual refrigerant may conceivably be dissolved in refrigerator oil.

(Example 2)

A test was conducted to recover a refrigerant under the following conditions as in the case of Example 1.

Refrigerant: R21 [dichlorofluoromethane], R22 [chlorodifluoromethane], R14 [tetrafluoromethane], R508 [trifluoromethane/hexafluoromethane mixed refrigerant]

Refrigerant charge amount: 463 g

Refrigerant recovery tank capacity: about 5 liters

Activated carbon: granular activated carbon using coconut husk in the form of pellets of 8 to 10 mesh and grain diameter 1.70 to 2.00 mm as a main raw material, the amount of use: 2020 g, and the activated carbon, when used, was wrapped in unwoven cloth as shown in FIG. 1.

The following shows results of measurement.

Elapsed time (min.)	Amount of recovered refrigerant (g)	Pressure (MPaG)
5	-	0.02
10	320	0.01
21	325	-0.03

For the recovery of the refrigerant, the opening/closing valve 8 was first closed, the opening/closing valve 17 was opened to connect the vacuuming line 16 to the not-shown vacuum pump, the vacuum pump was actuated to

execute vacuuming, and vacuuming was executed beforehand (3.6 Pa) in the refrigerant recovery tank 10. When the refrigerant was recovered, the opening/closing valve 17 was closed, the opening/closing valve 8 was opened, and the amount of the recovered refrigerant adsorbed on the activated carbon with the elapse of time, and pressure indicated by the pressure gauge 12 were measured.

Thus, a recovery rate of 69.1% was obtained in about 10 min. If the refrigerant can be recovered up to about pressure of -0.01 MPa, no residual refrigerant is discharged from the refrigeration circuit into the atmosphere. The residual refrigerant, especially high boiling point R21 and R22, may conceivably be dissolved in refrigerator oil. Thus, by processing the refrigerator oil, the residual refrigerant can be processed.

(Example 3)

A test was conducted to recover a refrigerant under the following conditions by using a large charge amount large-size machine at a binary refrigeration circuit as in the case of Example 1.

Refrigerant: high-temperature side; R412A

[chlorodifluoromethane, octafluoropropane, 1-chloro-1,1-difluoroethane], low-temperature side; R508 [trifluoromethane, hexafluoromethane mixed refrigerant]

Refrigerant charge amount: 345 g

Refrigerant recovery tank capacity: about 5 liters

Test temperature: 26°C

Activated carbon: granular activated carbon using coconut husk in the form of pellets of 8 to 10 mesh and grain diameter 1.70 to 2.00 mm as a main raw material, the amount of use: 2020 g, and the activated carbon, when used, was wrapped in unwoven cloth as shown in FIG. 1.

The refrigerant of the high-temperature side was recovered by a conventional method which used a recovery machine.

In the case of recovery of the refrigerant of the low-temperature side, the opening/closing valve 8 was first closed, the opening/closing valve 17 was opened to connect the vacuuming line 16 to the not-shown vacuum pump, the vacuum pump was actuated to execute vacuuming, and vacuuming was executed beforehand (3.6 Pa) in the refrigerant recovery tank 10. When the refrigerant was recovered, the opening/closing valve 17 was closed, the opening/closing valve 8 was opened, and the amount of the recovered refrigerant adsorbed on the activated carbon with the elapse of time to be recovered, and pressure indicated by the pressure gauge 12 were measured.

The following shows results of the measurement.

elapse of time (min.)	Amount of recovered refrigerant (g)	Pressure (MPaG)
10	-	-0.02
15	310	-0.02

Thus, a recovery rate of 89.9% was obtained in about 15 min. If the refrigerant can be recovered up to about pressure of -0.01 MPa, no residual refrigerant is discharged

from the refrigeration circuit into the atmosphere. The residual refrigerant may conceivably be dissolved in refrigerator oil.

The examples of recovering the low boiling point refrigerants such as R508 have been described. However, the present invention is not limited to the examples. For example, high boiling point refrigerants can be recovered.

The present invention provides the following marked effects. That is, the refrigerant recovery device comprising the refrigerant recovery tank which stores the activated carbon for adsorbing the refrigerant is characterized in that the recovery tank is equipped with the detachable cap, and the activated carbon is wrapped in the unwoven cloth finer than a grain diameter of the activated carbon, and stored in the recovery tank. Since the activated carbon is wrapped in the unwoven cloth finer than the grain diameter of the activated carbon, and stored in the recovery tank, handleability is improved, and a problem of a scattered loss to the outside is eliminated. The cap detachably attached to the recovery tank is opened/closed to enable handling of the activated carbon in its wrapped state in the unwoven cloth, and storage and replacement of the activated carbon can be easily carried out. Additionally, since the activated carbon is wrapped in the unwoven cloth finer than the grain diameter of the activated carbon, and stored in the recovery tank, there is no problem of sucking into the vacuum pump when the gas in the refrigerant recovery tank is vacuumed to be

discharged, the refrigerant can be recovered at low costs, and the device can be made compact and portable.

The present invention provides the following marked effect. That is, the refrigerant recovery method is characterized by comprising: connecting the refrigerant recovery device to the refrigeration circuit; and vacuuming a gas in the refrigerant recovery tank to discharge the gas before the refrigerant of the refrigeration circuit is recovered. The refrigerant can be efficiently recovered if the refrigerant of the refrigeration circuit is recovered after the gas in the refrigerant recovery tank is vacuumed.

The present invention provides the following marked effect. That is, in the refrigerant recovery method, the filter of the unwoven cloth finer than the grain diameter of the activated carbon is arranged on the path of the vacuuming. The activated carbon is captured by the filter even if the activated carbon is leaked from the refrigerant recovery tank during vacuuming. Thus, it is possible to prevent sucking into the vacuum pump.

Furthermore, the present invention provides the following marked effect. That is, in the refrigerant recovery method, the refrigerant is the low boiling point gas refrigerant or the mixture of the low boiling point gas refrigerant and the liquefied refrigerant which has a boiling point higher than that of the gas refrigerant. Even in the case of the low boiling point gas refrigerant which cannot be liquefied by pump-down running, or the mixture of the low

boiling point gas refrigerant and the liquefied refrigerant which has the boiling point higher than that of the gas refrigerant, the refrigerant can be recovered by adsorbing it on the activated carbon in the refrigerant recovery tank.